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BULLETIN No. 238

FEEDING FARM WORK HORSES
AND MULES

BY J. L. EDMONDS AND W. G. KAMMLADE



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Summary of Bulletin No. 238

Corn is a good grain feed for horses and mules doing farm work. In contradiction to the opinion sometimes expressed that corn is not good for horses and mules, these experiments have shown that *sound* ear corn properly fed with legume roughages is a healthful and satisfactory feed. For the roughage part of the ration, no common feeds are likely to prove more desirable than *good quality* legume hays. Clover and alfalfa in particular may be grown with the assurance that they may be fed both safely and economically to farm work animals. Wherever they are produced in the corn belt, they may safely be made the basic roughages for horses and mules.

Ear corn and alfalfa hay alone are sufficient to maintain farm horses and mules doing a considerable amount of medium to hard work. However, even tho this is true, our experience further leads us to believe that more satisfactory rations may be made and perhaps more economical feeding practiced when part of the alfalfa or clover roughage is replaced with timothy hay, oat hay, oat straw, prairie hay, or corn stover. The grain ration may be improved in variety and bulk by replacing about one-third of the corn with oats.

Farm-grown feeds need no special preparation to be successfully fed to either horses or mules. No condiments or commercial mixed feeds of any kind were used during these tests, which covered a period of three and one-half years; and under farm conditions there would be even less occasion to use prepared feeds or medicinal mixtures, for there would be an opportunity to use a greater variety of feeds and to make some use of pasture.

Recommendations for feeding farm work stock, based on these experiments, would be: To use home-grown feeds. To make legume hay an important part of the roughage, feeding it along with ear corn, or preferably ear corn and oats. And as a general rule to feed approximately one pound of grain and one pound of roughage per hundred pounds of live weight per day, varying the amounts as conditions indicate by increasing the amount of grain when the animals are at hard work and decreasing the grain and increasing the roughage when they are doing light work or are idle.

FEEDING FARM WORK HORSES AND MULES

BY J. L. EDMONDS, CHIEF IN HORSE HUSBANDRY, AND
W. G. KAMMLADE, ASSOCIATE IN ANIMAL HUSBANDRY

INTRODUCTION

More than 75 percent of the corn produced in Illinois is fed to farm animals. When corn is used in any feeding operations, it is always recommended that it be fed with feeds containing considerable protein and mineral matter in order that the ration may be properly balanced and prove suitable and adequate to the needs of the animals. Corn is superior to any other common feed for the production of work.¹

The growing appreciation in the corn belt of the marked benefits to be derived from the use of legumes in crop rotations is resulting in a steady increase in the production of these crops. At the present time there is no more satisfactory means of disposing of them than as feed for the live stock on the farms on which the crops are grown.

There has been considerable opposition to the use of corn and skepticism concerning its value for farm work animals. Much of this feeling may be attributed to difficulties resulting from improper feeding and much to the unsuitable character of the corn which was used. Legume hays, too, have not been very generally used as feeds for horses and mules because they have been thought to cause digestive disorders and to reduce strength and endurance.

OBJECT OF EXPERIMENTS

The four experiments reported herein were undertaken in a small way with the equipment available, in order to determine the practicability of using corn and legume hays as the basic feeds for farm work horses and mules. The object was to secure information of value to the farmer concerning the use of rations composed largely or entirely of ear corn and legume roughages for work stock, and to be able to give some definite suggestions regarding the amounts required and methods of feeding. Corn was selected as the main grain feed because it is grown so extensively in Illinois and its carbonaceous nature should make its use most satisfactory when it is fed with protein roughages.

Could these feeds form the basis of suitable and economical rations for farm work animals?

NOTE.—Mr. J. J. Yoke assisted in conducting these experiments until resigning in 1915.

¹*Feeds and Feeding*, by Henry and Morrison, page 285.

PLAN

Animals Used.—Two horse and two mule teams were used in each of the experiments. All the animals were rugged, useful workers. The horses were high-grade drafters. In the first experiment a team of ten-year-old mares and a team of four-year-old geldings were used. In the second experiment three five-year-old geldings replaced the two mares and one of the geldings of the first experiment. In the third experiment a five-year-old gelding replaced one of the geldings used previously. There were no changes for the fourth experiment. The average weight of the horses in the first experiment was approximately 1,500 pounds; in the second 1,560 pounds; and in the third and the fourth experiments about 1,640 pounds.

The same mules were used thruout the four experiments. They were a pair of mare mules and a pair of horse mules five and six years old respectively at the beginning of the first experiment. Their average weight was a little more than 1,350 pounds. On the market they would have classed as draft mules.

Method of Feeding.—The horses and mules were fed the same kinds and quality of feed; each animal received as much grain and hay, weighed separately, as it would eat readily. It seldom happened that any feed was left, but when this did occur the amount given was reduced in subsequent feedings so that there was no waste. The grain was fed in three equal amounts each day. One-half of the hay ration was divided between the morning and noon feeds, and the other half was fed at night. On Sundays and other idle days the grain was reduced at least one-third.

All the feeds used in these experiments were home-grown and of choice quality.

Water was given in the morning after feeding, before and after the noon feeding, before the evening feeding, and again at nine o'clock at night. This last drink was very refreshing to the animals, especially during warm weather.

Stabling.—The animals were kept in a light, well-ventilated stable equipped with standing stalls having concrete floors. Shavings were used for bedding because they would not be eaten. Because of the lack of suitable yards and because the mules were shod thruout the year, the animals were not turned together as is commonly done. Individuals were allowed a few hours exercise in a small dry lot on all idle days.

Nature of Work.—All teams were used regularly in doing farm work and general teaming. The farm work consisted for the most part of the tilling of small fields; in addition a number of acre plots were tilled. A considerably larger proportion of the work consisted of heavier hauling than is the case on most farms. Loads amounting

to three tons net weight per team were frequently drawn from town to the University stock barns, a distance of about two miles.

Records.—Records were kept of the weights of the animals, the amounts of feeds consumed, the number of hours of labor performed, and the distances traveled.

Weighings were made before watering on one morning of every week during the experiments. The mileage records of the first and second trials are for the most part close estimates computed from field measurements, tho in some cases the distances traveled were measured by means of an odometer on a two-wheeled cart. No mileage records were secured in the third experiment. In the fourth experiment small two-wheeled carts, equipped with odometers, were attached to all the implements and wagons to which the horses and mules were hitched.

DISCUSSION OF RESULTS WITH HORSES

THE 1912 EXPERIMENT

In the first experiment clover hay was fed with a grain ration consisting of two-thirds ear corn and one-third oats by weight. The spirit and appearance, and weights and gains of the animals during the experiment showed the clover to be a very satisfactory roughage.

It will be noted from Table 1 that the amounts of grain fed were rather high. While the feed costs could have been reduced by feeding a little less grain and more hay, it is probable that the gains would have been less. The good results in feeding clover hay were doubtless largely due to the use of clover of first quality and to the limiting of the amount fed to about one pound per hundredweight per day. The fact that the trial was of 364 days' duration would indicate that the ration used might be safely and satisfactorily employed over a long period of time with farm work horses in general. The results of this experiment are similar to those of previous experiments reported by this Station, which have demonstrated clover hay to be a suitable feed for work horses.¹ Ear corn and oats make a good grain ration to feed with clover hay.

It is worth while to call attention to the feeding standard for work horses as shown by the Modified Wolff-Lehmann Standards.² According to this standard, horses weighing approximately 1,500 pounds, doing medium work, require in their ration from 24 to 36 pounds of dry matter per day; 2.10 to 2.55 pounds of digestible crude protein; 19.2 to 23.4 pounds of total digestible nutrients; and the ration should have a nutritive ratio of 1:7.8 to 8.3; that is, for every pound of digestible crude protein there should be about eight pounds of carbohydrates and fat equivalent. (In calculating the nutritive

¹ See Bulletin 150, *Feeding Farm Work Horses*, by R. C. Obrecht, August, 1911.

² *Feeds and Feeding*, by Henry and Morrison, page 671.

TABLE 1.—SUMMARY OF FEEDING EXPERIMENTS WITH FARM WORK HORSES
Showing Rations Fed and Average Weight, Feed Consumption, and Work
per Horse

Ration		1912	1913	1914-15	1916-17
		Ear corn $\frac{2}{8}$ Oats $\frac{1}{8}$	Ear corn $\frac{2}{8}$ Oats $\frac{1}{8}$	Ear corn $\frac{2}{8}$ Oats $\frac{1}{8}$	Ear corn
	Grain				
	Roughage	Clover hay	Clover $\frac{1}{2}$ Timothy $\frac{1}{2}$	Alfalfa or Alfalfa $\frac{1}{2}$ Timothy $\frac{1}{2}$	Alfalfa hay
Length of trial, days.....		364	140	364	364
Weight:					
	Av. weight at beginning, lbs.	1445	1578	1621	1636
	Av. weight at close.....	1585	1566	1626	1666
	Gain or loss.....	+140	-12	+6	+30
	Av. weight during trial.....	1497	1564	1639	1639
Grain:					
	Total ear corn eaten, lbs....	4400	1503	4376	5470
	Total oats eaten.....	2200	752	2188	.....
	Total grain eaten.....	6600	2255	6564	5470
	Av. grain per day.....	18.13	16.11	18.03	15.77
	Av. grain per cwt. per day..	1.21	1.03	1.10	.96
Hay:					
	Total hay eaten, lbs.....	5251	2044	6164	6823
	Av. hay per day.....	14.43	14.60	16.93	18.75
	Av. hay per cwt. per day...	.96	.93	1.03	1.14
Hours of labor:					
	Total hours of labor.....	2503	990	2517	2517
	Av. hours per work day.....	8.02	8.25	8.07	8.07
	Number of idle work days...	28	17	33	29.5
Travel:					
	Total miles traveled.....	2782	1259	(¹)	2960
	Av. miles per hour.....	1.11	1.27	(¹)	1.18

NOTE:—Records of each individual may be found in the tables in the Appendix, pages 424-427.

¹No records were obtained during the 1914-15 experiment.

ratio, the fat is multiplied by $2\frac{1}{4}$ in order to give its energy value in terms of carbohydrates.)

While no attempt was made to feed these horses according to this standard, the ration fed did correspond quite closely with these requirements. It supplied approximately 26.70 pounds of dry matter; 2.41 pounds of digestible crude protein; and 19.88 pounds of total digestible nutrients; and had a nutritive ratio of 1:7.25.¹ The results secured with this ration would seem to indicate that the Modified Wolff-Lehmann Standard is a reliable guide for feeding work horses.

The labor record of 8.02 hours per horse per work day may be considered very good, for the hours of labor usually given as the

¹Computed from the nutrient composition of feeds as given by the above authorities, pages 653-666 of *Feeds and Feeding*.

average for farm horses is about 3.5 per work day. (The number of work days is calculated by deducting Sundays; hence, there are 312 in a year.)

The mileage record is only approximately correct, as the distances were frequently closely estimated rather than accurately measured. It is a very close estimate, however, and shows what may be accomplished with farm work horses if they are used to the best advantage in a system of diversified farming.

THE 1913 EXPERIMENT

The 1913 experiment, also reported in Table 1, included a period of but 140 days and on this account the data cannot have the same value as those for the other three tests, which covered 364 days each. This experiment does, however, include the period of rush work on the farm—April 27 to September 14.

The ration fed—two-thirds ear corn, one-third oats, by weight, and mixed hay (clover $\frac{1}{2}$ and timothy $\frac{1}{2}$)—was satisfactory so far as the character of the feeds was concerned, and doubtless there is some advantage in using a variety of feeds. The amounts fed, however, were not sufficient to maintain the average initial weight of the horses, as is shown by the loss in weight at the end of the experiment and by the average weight during the experiment, which was less than either the initial or the final weight.

The nutrients supplied in this ration are about the minimum or a little less than the minimum requirements given by the Modified Wolff-Lehmann Standard for a 1,600-pound horse doing medium work. These horses were doing hard work, so that it is not surprising that the ration was not sufficient to maintain their weights. If the same feeds were used, but in larger amounts than in this trial, there would seem to be no reason why the ration should not be found entirely satisfactory for farm work horses for use over a long period.

The horses worked an average of 8.25 hours per work day. Both the labor record and the number of miles traveled were considerably reduced in this test by the record of one horse. Three of the horses worked an average of almost 8.75 hours per work day and traveled more than 1,300 miles each. The fourth horse was susceptible to frequent attacks of colic and averaged about two hours less work per work day and traveled 300 miles less than the other three. This fact, of course, resulted in a reduction in the average labor and mileage records, which even with this reduction are exceptionally good.

THE 1914-15 EXPERIMENT

The grain feeds in the 1914-15 experiment were the same and were fed in the same proportions as in the two previous experiments. One horse in each team was fed alfalfa hay, and the other horse, alfalfa

$\frac{1}{2}$ and timothy $\frac{1}{2}$. However, there was so little variation in the amounts of grain and hay consumed and the number of animals was so small that it is impossible to make a definite comparison of the two hay rations.

The alfalfa hay proved a palatable and healthful feed, causing no functional disturbances, digestive or otherwise. It was well cured and sound but was rather brown and stemmy. The fact that equal amounts of alfalfa and timothy in the ration proved so successful would indicate that if alfalfa is high in price it might be advisable to replace part of it with timothy. It might also be profitable to substitute other carbonaceous roughages, such as corn stover or oat straw, for the timothy in this ration and secure good results and a reduction in costs.

While the alfalfa, ear corn, and oats made a good ration, the requirements of these horses—whose weights averaged about 1,640 pounds and who were doing medium work—were, in some particulars, more closely met by the alfalfa, timothy, ear corn, and oats ration. The following tabulation shows the Modified Wolff-Lehmann Standard for 1,640-pound horses at medium work and the nutrients supplied per day by the rations used in this experiment.

	Dry matter lbs.	Digestible crude protein lbs.	Total digest- ible nutrients lbs.	Nutritive ratio
Required by Modified Wolff-Lehmann Standard...	26.24-39.36	2.29-2.79	20.99-25.58	1:7.8-8.3
Supplied by the ration of—				
Alfalfa, ear corn, and oats (average for 2 horses).....	29.58	3.10	21.22	1:6.0
Alfalfa, timothy, ear corn and oats (average for 2 horses)	29.19	2.45	20.89	1:7.6

These figures show that the timothy reduced the supply of protein to a little nearer the average requirements and thus gave a wider nutritive ratio. Under farm conditions it is probably best to feed alfalfa as one-half to two-thirds of the roughage ration rather than as the sole roughage. An over supply of protein may not be injurious, but as protein is frequently the most expensive nutrient in the ration it is of advantage, in preventing excessive cost of feed, to keep the supply of protein down to the requirement.

The average gain in weight (6 pounds) was entirely due to a gain of 75 pounds by one horse. Two of the horses lost 25 pounds each and the fourth neither gained nor lost.

The labor record of 8.07 hours per horse per work day was a little better than the record in 1912 of 8.02 hours. No mileage data were obtained in this trial.

THE 1916-17 EXPERIMENT

The 1916-17 experiment is probably the most important of this series of tests, particularly because of the fact that thruout an entire year only two feeds were used in maintaining the work horses, and furthermore because of the fact that these two feeds are rather commonly considered, at least in some sections, as poor feeds for horses. For 364 days the horses in this test were given only ear corn and alfalfa hay, and during most of this time they worked at farm work and general teaming that would class as medium to hard work. The data are presented in Table 1.

As the figures show a good weight for the horses during the experiment and an average gain of 30 pounds over their initial weight, the ration must be considered a success from the standpoint of being sufficient to maintain weight. Observations of the health, condition, thrift, and spirit of the animals also showed the ration to be successful. The chief criticism would be that the lack of variety in the ration caused some decrease in appetite, and hence the horses were lacking in an extremely sleek appearance, particularly just before the close of the test. It should be mentioned in this connection that the summer of 1916, during which this experiment was conducted, was so hot and dry as to be a severe test for any system of feeding.

The average consumption of ear corn per hundredweight per day was a little under one pound, and the daily consumption of alfalfa hay was only 1.14 pounds per hundredweight. The use of alfalfa hay evidently reduced the grain requirement. The alfalfa used in this test had been in the barn a year, was well cured, sound, and was not so leafy as choice pea-green hay. The advantage of using a nutritious roughage is apparent when feed costs are considered, particularly if grains are high in price.

This ration supplied approximately 28.43 pounds of dry matter, 2.93 pounds of digestible crude protein, and 20.50 pounds of total digestible nutrients. The amount of total digestible nutrients corresponds closely to the Modified Wolff-Lehmann Standard. However, the amount of protein supplied was somewhat in excess of the requirement, and for this reason the nutritive ratio was narrower than it needed to be.

While these two feeds contained an abundance of nutrients and were successfully used in this experiment, they would not be considered the most desirable combination for feeding farm work horses for a whole year or longer where conditions made it possible to use a greater variety of feeding stuffs and possibly make some use of pasture at night and on idle days during the summer. Under farm conditions some oats might be fed with the corn, and some carbonaceous roughage, such as timothy, prairie hay, oat hay, oat straw, or

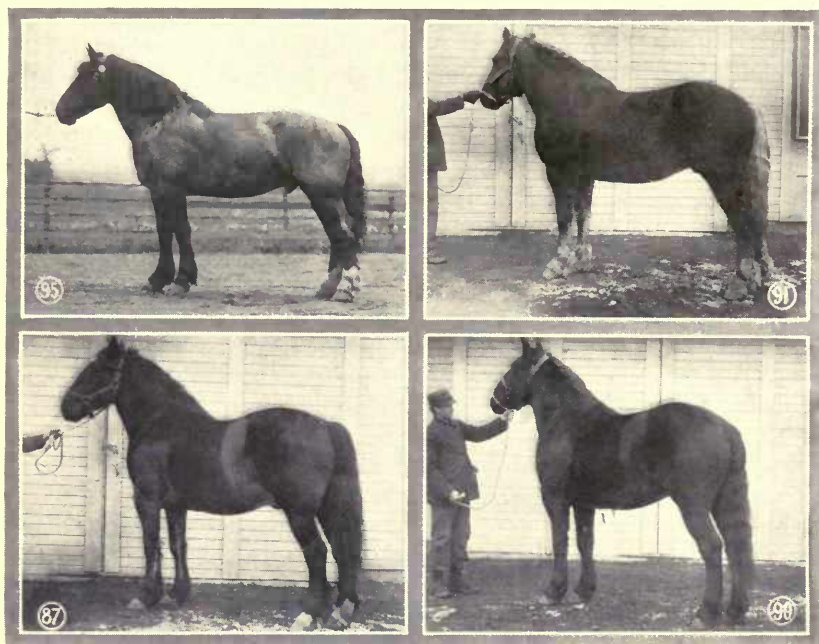


FIG. 1.—FOUR OF THE HORSES USED IN THE EXPERIMENTS

The condition, appearance, spirit, and weights of these horses would seem to demonstrate that ear corn and good legume hays are very satisfactory basic feeds for farm work horses. The pictures show the horses near the close of the last experiment. Nos. 91, 87, and 90 were used in the last three experiments; No. 95 in the last two only.

corn stover, might well form at least one-third of the roughage. These substitutions would usually result in a reduction of feed costs and the ration would undoubtedly be improved thru the use of a variety of feeds. However, ear corn and alfalfa hay may be used to a rather large extent in making up rations for work horses. They are highly desirable feeds, both because of their nutritive value and because of their suitability for the best corn-belt cropping practices.

The labor record of 8.07 hours per horse per work day is very good and would have been better had it not been for a shortage of teamsters during part of October and November, which reduced the use of the horses. The record of the distances traveled is accurate in this experiment, the measurements having been made by means of odometers on small carts attached to all the implements to which the horses were worked.

COST OF FEED

The cost of feed is usually estimated as amounting to about 75 percent of the entire cost of the keep of horses, and it is one of the places where the man who owns horses may well attempt to reduce his operating expense. As a help in this direction Table 2 is presented showing the average total and daily cost of feed as based on four different sets of feed prices for each of the four different rations used.

In this table total feed consumption will be found expressed in bushels and tons also, so that anyone can easily figure for himself the cost at prices prevailing in his community and thus arrive at figures of more value to him.

The 1913 experiment shows the lowest feed cost per day, but it should be remembered that the horses in this experiment were not fed sufficient amounts to prevent losses in weight.

TABLE 2.—AVERAGE TOTAL AND DAILY COST OF FEED FOR FARM WORK HORSES BASED ON VARIOUS PRICES

(For feed prices see bottom of page)

		A	B	C	D
1912: 364 days					
Ear corn.....	62.86 bu.	\$35.20	\$40.86	\$31.43	\$62.86
Oats.....	68.75 bu.	27.50	27.50	22.00	41.25
Clover.....	2.63 tons	31.56	36.82	26.30	42.08
Total cost.....		\$94.26	\$105.18	\$79.73	\$146.19
Cost per day.....		.258	.289	.219	.402
1913: 140 days					
Ear corn.....	21.47 bu.	\$12.03	\$13.96	\$10.74	\$21.47
Oats.....	23.50 bu.	9.40	9.40	7.52	14.10
Clover.....	.51 ton	6.13	7.14	5.10	8.16
Timothy.....	.51 ton	8.16	7.14	5.10	8.16
Total cost.....		\$35.72	\$37.64	\$28.46	\$51.89
Cost per day.....		.255	.269	.203	.371
1914-15: 364 days					
Ear corn.....	62.51 bu.	\$35.01	\$40.63	\$31.26	\$62.51
Oats.....	68.37 bu.	27.36	27.36	21.88	41.02
Alfalfa and timothy..	3.08 tons	49.28	43.12	36.96	49.28
Total cost.....		\$111.65	\$111.11	\$90.10	\$152.81
Cost per day.....		.306	.305	.248	.420
1916-17: 364 days					
Ear corn.....	82.00 bu.	\$45.92	\$53.30	\$41.00	\$82.00
Alfalfa.....	3.41 tons	54.56	47.74	40.92	54.56
Total cost.....		\$100.48	\$101.04	\$81.92	\$136.56
Cost per day.....		.276	.277	.225	.375

Feed Prices:

	A	B	C	D
Corn, per bushel.....	\$.56	\$.65	\$.50	\$ 1.00
Oats, per bushel.....	.40	.40	.32	.60
Clover, per ton.....	12.00	14.00	10.00	16.00
Timothy, per ton.....	16.00	14.00	10.00	16.00
Alfalfa, per ton.....	16.00	14.00	12.00	16.00

In the 1914-15 trial the timothy and alfalfa were figured at the same price per ton.

DISCUSSION OF RESULTS WITH MULES

The results of the experiments with mules will not be discussed separately in as much detail as the experiments with the horses since the same rations were used as for the horses and the remarks concerning the horses will apply here also. The recommendations for improving the rations for horses might also be made for improving the rations for mules.

The Modified Wolff-Lehmann Standards contain no table of requirements for mules. For the following tabulation the mule's requirements are assumed to be the same as the requirements for horses of the same weight. This may or may not be correct; at best it is an assumption and is not based on definite established knowledge. It is used, however, because there is apparently no other standard adapted for the purpose. (The amounts given are based on the average daily ration.)

	Dry matter lbs.	Digestible crude protein lbs.	Total digestible nutrients lbs.	Nutritive ratio
Requirements for 1,360-lb. horse at medium work.....	21.76-32.64	1.90-2.31	17.41-21.22	1:7.8-8.3
Supplied by a ration of—				
Ear corn, oats; clover (1912) ..	22.84	2.05	16.69	1:7.1
Ear corn, oats; clover $\frac{1}{2}$ and timothy $\frac{1}{2}$ (1913)	19.56	1.48	14.08	1:8.5
Ear corn, oats; alfalfa (1914- 15) (average for 2 mules) ..	22.71	2.40	16.12	1:5.7
Ear corn, oats; alfalfa $\frac{1}{2}$ and timothy $\frac{1}{2}$ (1914-15) (aver- age for 2 mules)	22.75	1.90	16.11	1:7.5
Ear corn; alfalfa (1916-17) ..	23.22	2.43	16.35	1:5.73

The 1912 ration of ear corn, oats, and clover hay, and the 1914-15 ration of ear corn, oats, alfalfa $\frac{1}{2}$ and timothy $\frac{1}{2}$ more nearly supplied the requirements of the mules, according to this tabulation, than did any of the other rations. This was also the observation made during the progress of these experiments. The figures show, too, that the nutrients supplied in 1913 were about in the proper proportion but were insufficient in amount even for mules doing medium work, and the work which these mules did during the test would be classed as hard work. The insufficiency of the ration, so far as amount supplied is concerned, is further shown in Table 3 by the loss of weight by the mules. Only in this one particular was this ration at all unsatisfactory. The feeds used in this trial, so far as their character is concerned, are suitable for mules at medium or hard work.

The ear corn and alfalfa used in the 1916-17 experiment were ample to maintain the weights of the animals and to supply energy

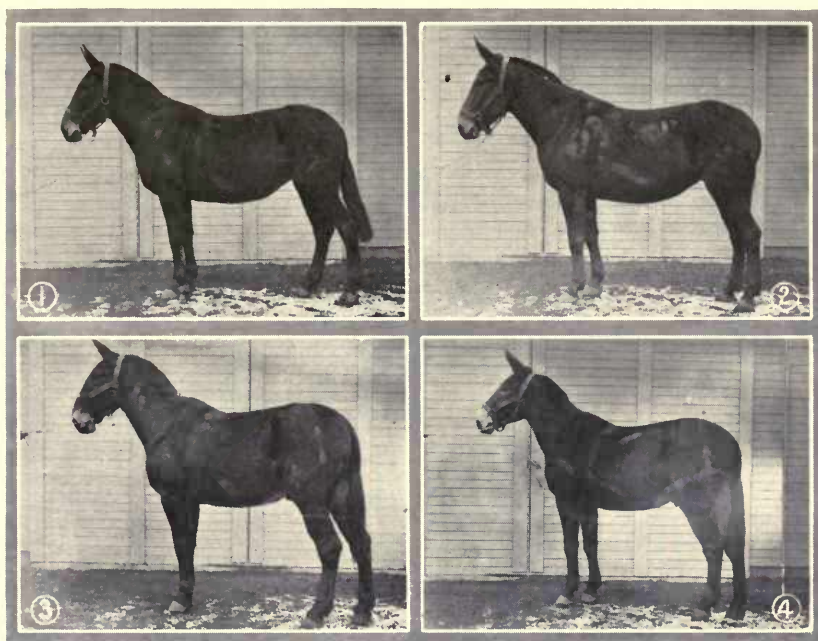


FIG. 2.—THE FOUR MULES USED IN THE EXPERIMENTS

These mules were used in all experiments reported in this bulletin. Rations composed largely of ear corn and legume hays kept them in good condition while doing medium to hard work. The pictures were taken near the close of the last experiment.

for them to do considerable work. The supply of protein was larger than necessary and the nutritive ratio was too narrow. This could have been remedied by the use of some roughage that contained less protein, such as timothy hay or oat straw, in place of about one-third or one-half of the alfalfa.

In general, those rations which most closely approached the requirements of the above standard were more satisfactory than those which showed rather marked deviations, except in the case of the 1913 experiment, which has already been explained.

In all four experiments with mules the labor record is very satisfactory. The average amount of labor per mule per work day was 8.06 hours for the first experiment; 8.69 hours for the second; 8.43 hours for the third; and 8.25 hours for the fourth. In all the trials the mules worked an average of more than 90 percent of the total number of work days.

TABLE 3.—SUMMARY OF FEEDING EXPERIMENTS WITH MULES
Showing Rations Fed, Average Weight, Feed Consumption, and Work per Mule

Ration	1912	1913	1914-15	1916-17
{ Grain	Ear corn $\frac{2}{8}$	Ear corn $\frac{2}{8}$	Ear corn $\frac{2}{8}$	Ear corn
	Oats $\frac{1}{8}$	Oats $\frac{1}{8}$	Oats $\frac{1}{8}$	
{ Roughage	Clover hay	Clover $\frac{1}{2}$	Alfalfa or	Alfalfa hay
		Timothy $\frac{1}{2}$	Alfalfa $\frac{1}{2}$	
		Timothy $\frac{1}{2}$	Timothy $\frac{1}{2}$	
Length of trial, days	364	140	364	364
Weight:				
Av. weight at beginning, lbs.	1337	1401	1349	1290
Av. weight at close	1428	1374	1315	1343
Gain or loss	+91	-27	-33	+54
Av. weight during trial	1358	1370	1348	1356
Grain:				
Total ear corn eaten, lbs. . . .	3437	1120	3202	4187
Total oats eaten	1718	560	1601	.....
Total grain eaten	5155	1680	4803	4187
Av. grain per day	14.16	12.00	13.20	11.50
Av. grain per cwt. per day . .	1.04	.88	.98	.85
Hay:				
Total hay eaten, lbs.	4930	1628	4971	5971
Av. hay per day	13.54	11.62	13.66	16.40
Av. hay per cwt. per day . .	1.00	.85	1.01	1.22
Hours of labor:				
Total hours of labor	2515	1043	2628	2575
Av. hours labor per work day	8.06	8.69	8.43	8.25
Number of idle work days . .	23	9.5	21	27.5
Travel:				
Total miles traveled	2863	1451	(1)	3000
Av. miles per hour	1.14	1.39	(1)	1.17

NOTE.—Records of each individual may be found in the tables in the Appendix, pages 424-427.

¹No records were obtained during the 1914-15 experiment.

COST OF FEED

Table 4 shows the cost of the feed for the mules for all the experiments. It is constructed in the same way as the table of feed cost given for the horses.

Here, too, the lowest cost per day is for the 1913 trial, during which time the ration fed was not sufficient to maintain the weights of the mules. The cost in this experiment would of course be larger if the feed had been sufficient in quantity to maintain the weights of the animals.

TABLE 4.—AVERAGE TOTAL AND DAILY COST OF FEED FOR MULES, BASED ON VARIOUS PRICES

(For feed prices see bottom of page)

		A	B	C	D
1912: 364 days					
Ear corn.....	49.10 bu.	\$27.50	\$31.92	\$24.55	\$49.10
Oats.....	53.71 bu.	21.48	21.48	17.18	32.23
Clover.....	2.47 tons	29.64	34.58	24.70	39.52
Total cost.....		\$78.62	\$87.98	\$66.43	\$120.85
Cost per day.....		.216	.242	.183	.332
1913: 140 days					
Ear corn.....	16.00 bu.	\$ 8.96	\$10.40	\$ 8.00	\$16.00
Oats.....	17.50 bu.	7.00	7.00	5.60	10.50
Clover.....	.41 ton	4.88	5.74	4.10	6.56
Timothy.....	.41 ton	6.51	5.74	4.10	6.56
Total cost.....		\$27.35	\$28.88	\$21.80	\$39.62
Cost per day.....		.195	.206	.155	.283
1914-15: 364 days					
Ear corn.....	45.74 bu.	\$25.62	\$29.73	\$22.87	\$45.74
Oats.....	50.03 bu.	20.01	20.01	16.01	30.02
Alfalfa and timothy..	2.49 tons	39.84	34.86	29.88	39.84
Total cost.....		\$85.47	\$84.60	\$68.76	\$115.60
Cost per day.....		.235	.232	.189	.318
1916-17: 364 days					
Ear corn.....	59.81 bu.	\$33.49	\$38.88	\$29.91	\$59.81
Alfalfa.....	2.99 tons	47.84	41.86	35.88	47.84
Total cost.....		\$81.33	\$80.74	\$65.79	\$107.65
Cost per day.....		.223	.222	.181	.295
Feed Prices:					
Corn, per bushel.....		\$.56	\$.65	\$.50	\$ 1.00
Oats, per bushel.....		.40	.40	.32	.60
Clover, per ton.....		12.00	14.00	10.00	16.00
Timothy, per ton.....		16.00	14.00	10.00 ¹	16.00
Alfalfa, per ton.....		16.00	14.00	12.00	16.00

¹In the 1914-15 trial the timothy and alfalfa were figured at the same price per ton.

APPENDIX

A summary of the record for each individual in these experiments is contained in the following pages.

TABLE A.—SUMMARY OF 1912 FEEDING EXPERIMENT WITH HORSES: 364 DAYS
Ration: $\frac{2}{8}$ Ear Corn, $\frac{1}{8}$ Oats; Clover

Horses.....	No. 51	No. 52	No. 85	No. 86
<i>Weight:</i>				
Weight at beginning, lbs.....	1440	1460	1375	1505
Weight at end.....	1585	1550	1560	1645
Gain.....	145	90	185	140
Av. weight during trial.....	1497	1508	1438	1547
<i>Grain:</i>				
Total ear corn eaten, lbs.....	4192	4260	4276	4873
Total oats eaten.....	2096	2130	2138	2436
Total grain eaten.....	6288	6390	6414	7310
Av. grain per day.....	17.27	17.55	17.64	20.08
Av. grain per cwt. per day..	1.15	1.16	1.23	1.30
<i>Hay:</i>				
Total hay eaten, lbs.....	5096	5075	4998	5835
Av. hay per day.....	14.00	13.94	13.73	16.00
Av. hay per cwt. per day....	.93	.92	.95	1.03
<i>Hours of labor:</i>				
Total hours labor.....	2474	2584	2401	2552
Av. hours labor per work day	7.92	8.28	7.69	8.17
Number of idle work days...	35	17	41	18
<i>Travel:</i>				
Total miles traveled.....	2787	2867	2646	2828
Av. miles per hour.....	1.13	1.11	1.10	1.11

TABLE B.—SUMMARY OF 1913 FEEDING EXPERIMENT WITH HORSES: 140 DAYS
Ration: $\frac{2}{8}$ Ear Corn, $\frac{1}{8}$ Oats; $\frac{1}{2}$ Clover, $\frac{1}{2}$ Timothy

Horses.....	No. 86	No. 91	No. 87	No. 90
<i>Weight:</i>				
Weight at beginning, lbs.....	1600	1470	1630	1610
Weight at end.....	1560	1500	1570	1635
Gain or loss.....	-40	+30	-60	+25
Av. weight during trial.....	1575	1492	1585	1608
<i>Grain:</i>				
Total ear corn eaten, lbs.....	1320	1497	1600	1596
Total oats eaten.....	659	749	800	798
Total grain eaten.....	1979	2246	2400	2394
Av. grain per day.....	14.14	16.04	17.14	17.10
Av. grain per cwt. per day..	.90	1.08	1.08	1.06
<i>Hay:</i>				
Total hay eaten, lbs.....	2073	1962	2000	2142
Av. hay per day.....	14.81	14.01	14.29	15.30
Av. hay per cwt. per day....	.94	.94	.90	.95
<i>Hours of labor:</i>				
Total hours labor.....	1037	812	1062	1048
Av. hours labor per work day	8.64	6.77	8.85	8.73
Number of idle work days...	11	37	9	10
<i>Travel:</i>				
Total miles traveled.....	1362	1023	1321	1328
Av. miles per hour.....	1.31	1.26	1.24	1.26

TABLE C.—SUMMARY OF 1914-15 FEEDING EXPERIMENT WITH HORSES: 364 DAYS
 Ration: $\frac{2}{3}$ Ear Corn, $\frac{1}{8}$ Oats; Alfalfa, or $\frac{1}{2}$ Timothy and $\frac{1}{2}$ Alfalfa

Horses.....	No. 95	No. 91	No. 87	No. 90
<i>Weight:</i>				
Weight at beginning, lbs.....	1570	1590	1645	1680
Weight at end.....	1645	1565	1620	1680
Gain or loss.....	+75	-25	-25	.....
Av. weight during trial.....	1633	1578	1655	1686
<i>Grain:</i>				
Total ear corn eaten, lbs.....	4362	4374	4341	4426
Total oats eaten.....	2181	2187	2170	2213
Total grain eaten.....	6544	6562	6512	6639
Av. grain per day.....	17.98	18.03	17.89	18.24
Av. grain per cwt. per day..	1.10	1.14	1.08	1.08
<i>Hay:</i>				
Total alfalfa eaten, lbs.....	6083	2999	6291	3141
Total timothy eaten.....	.....	2999	.....	3141
Total hay eaten.....	6083	5998	6291	6282
Av. hay per day.....	16.71	16.48	17.28	17.26
Av. hay per cwt. per day....	1.02	1.04	1.04	1.02
<i>Hours of labor:</i>				
Total hours labor.....	2583	2595	2477	2415
Av. hours labor per work day	8.28	8.31	7.94	7.74
Number of idle work days...	27	26	39	41

TABLE D.—SUMMARY OF 1916-17 FEEDING EXPERIMENT WITH HORSES: 364 DAYS
 Ration: Ear Corn; Alfalfa

Horses.....	No. 95	No. 91	No. 87	No. 90
<i>Weight:</i>				
Weight at beginning, lbs.....	1670	1595	1600	1680
Weight at end.....	1680	1580	1665	1740
Gain or loss.....	+10	-15	+65	+60
Av. weight during trial.....	1662	1571	1618	1703
<i>Grain:</i>				
Total ear corn eaten, lbs.....	5512	5558	5886	6004
Av. ear corn per day.....	15.14	15.27	16.17	16.49
Av. ear corn per cwt. per day	.91	.97	1.00	.97
<i>Alfalfa:</i>				
Total alfalfa eaten, lbs.....	6430	6446	7220	7197
Av. alfalfa per day.....	17.66	17.71	19.84	19.77
Av. alfalfa per cwt. per day..	1.06	1.13	1.23	1.16
<i>Hours of labor:</i>				
Total hours labor.....	2495	2495	2539	2539
Av. hours labor per work day	8.00	8.00	8.14	8.14
Number of idle work days...	32	32	27	27
<i>Travel:</i>				
Total miles traveled.....	2966	2966	2955	2955
Av. miles per hour.....	1.19	1.19	1.17	1.17

TABLE E.—SUMMARY OF 1912 FEEDING EXPERIMENT WITH MULES: 364 DAYS
 Ration: $\frac{2}{3}$ Ear Corn, $\frac{1}{3}$ Oats; Clover

Mules.....	No. 1	No. 2	No. 3	No. 4
<i>Weight:</i>				
Weight at beginning, lbs.....	1360	1370	1315	1305
Weight at end.....	1440	1465	1380	1430
Gain.....	80	95	65	125
Av. weight during trial.....	1381	1376	1327	1351
<i>Grain:</i>				
Total ear corn eaten, lbs.....	3333	3515	3273	3627
Total oats eaten.....	1666	1757	1636	1813
Total grain eaten.....	4999	5272	4909	5441
Av. grain per day.....	13.74	14.49	13.49	14.95
Av. grain per cwt. per day..	.99	1.05	1.02	1.10
<i>Hay:</i>				
Total hay eaten, lbs.....	5062	5070	4792	4796
Av. hay per day.....	13.91	13.93	13.17	13.18
Av. hay per cwt. per day....	1.01	1.01	.99	.97
<i>Hours of labor:</i>				
Total hours labor.....	2477	2601	2523	2461
Av. hours labor per work day	7.94	8.34	8.09	7.89
Number of idle work days...	30	19	24	29
<i>Travel:</i>				
Total miles traveled.....	2872	3025	2815	2741
Av. miles per hour.....	1.16	1.16	1.11	1.11

TABLE F.—SUMMARY OF 1913 FEEDING EXPERIMENT WITH MULES: 140 DAYS
 Ration: $\frac{2}{3}$ Ear Corn, $\frac{1}{3}$ Oats; $\frac{1}{2}$ Clover, $\frac{1}{2}$ Timothy

Mules.....	No. 1	No. 2	No. 3	No. 4
<i>Weight:</i>				
Weight at beginning, lbs.....	1405	1410	1370	1420
Weight at end.....	1375	1355	1355	1410
Gain or loss.....	—30	—55	—15	—10
Av. weight during trial.....	1362	1380	1351	1390
<i>Grain:</i>				
Total ear corn eaten, lbs.....	1071	1149	1085	1175
Total oats eaten.....	535	575	542	588
Total grain eaten.....	1606	1724	1627	1763
Av. grain per day.....	11.47	12.31	11.62	12.59
Av. grain per cwt. per day..	.84	.89	.86	.91
<i>Hay:</i>				
Total hay eaten, lbs.....	1628	1628	1622	1633
Av. hay per day.....	11.63	11.63	11.59	11.66
Av. hay per cwt. per day....	.85	.84	.86	.84
<i>Hours of labor:</i>				
Total hours labor.....	1066	966	1065	1075
Av. hours labor per work day	8.88	8.05	8.88	8.95
Number of idle work days...	10	20	4	4
<i>Travel:</i>				
Total miles traveled.....	1383	1283	1564	1575
Av. miles per hour.....	1.30	1.33	1.46	1.46

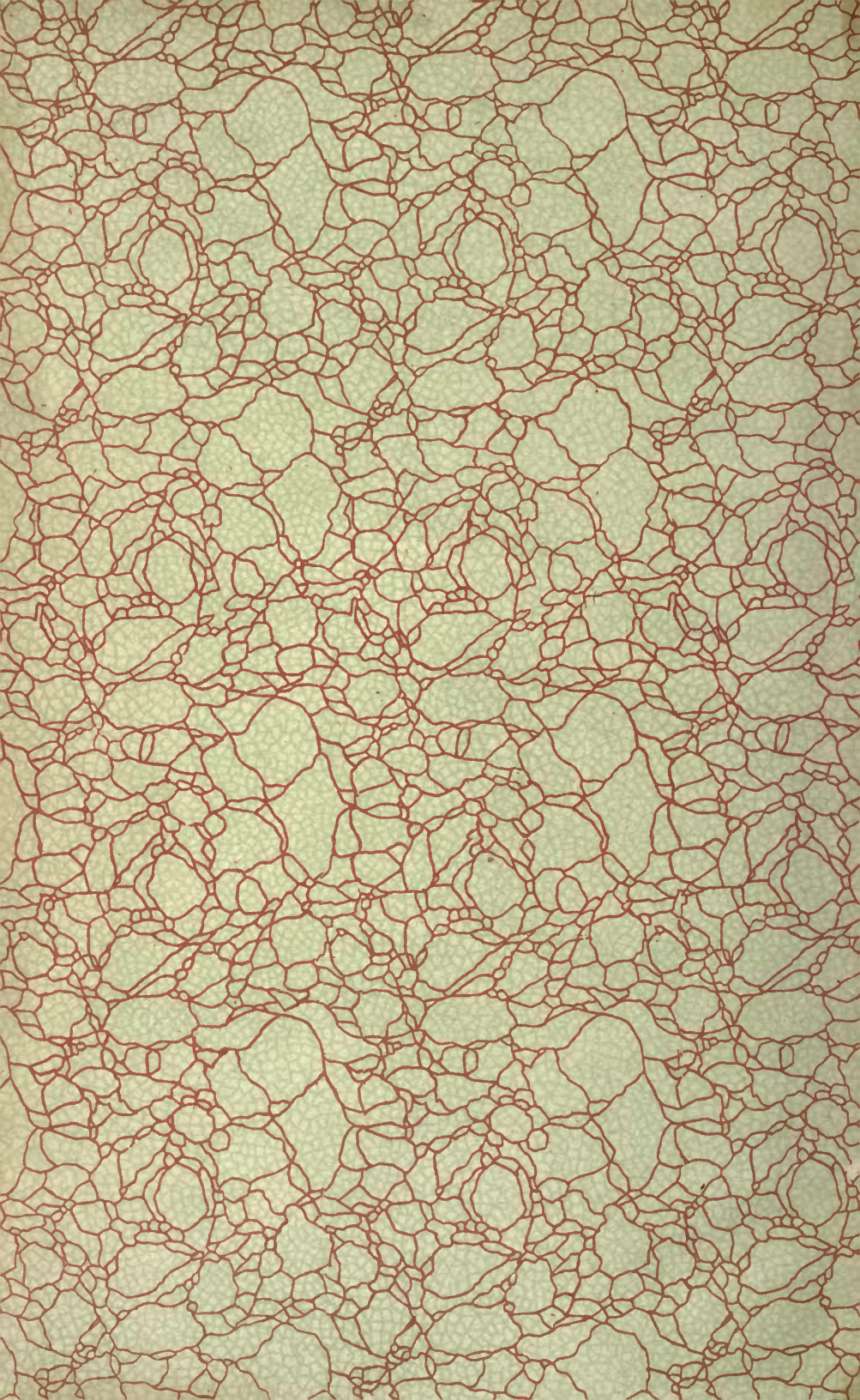
TABLE G.—SUMMARY OF 1914-15 FEEDING EXPERIMENT WITH MULES: 364 DAYS
 Ration: $\frac{2}{3}$ Ear Corn, $\frac{1}{3}$ Oats; Alfalfa, or $\frac{1}{2}$ Timothy, $\frac{1}{2}$ Alfalfa

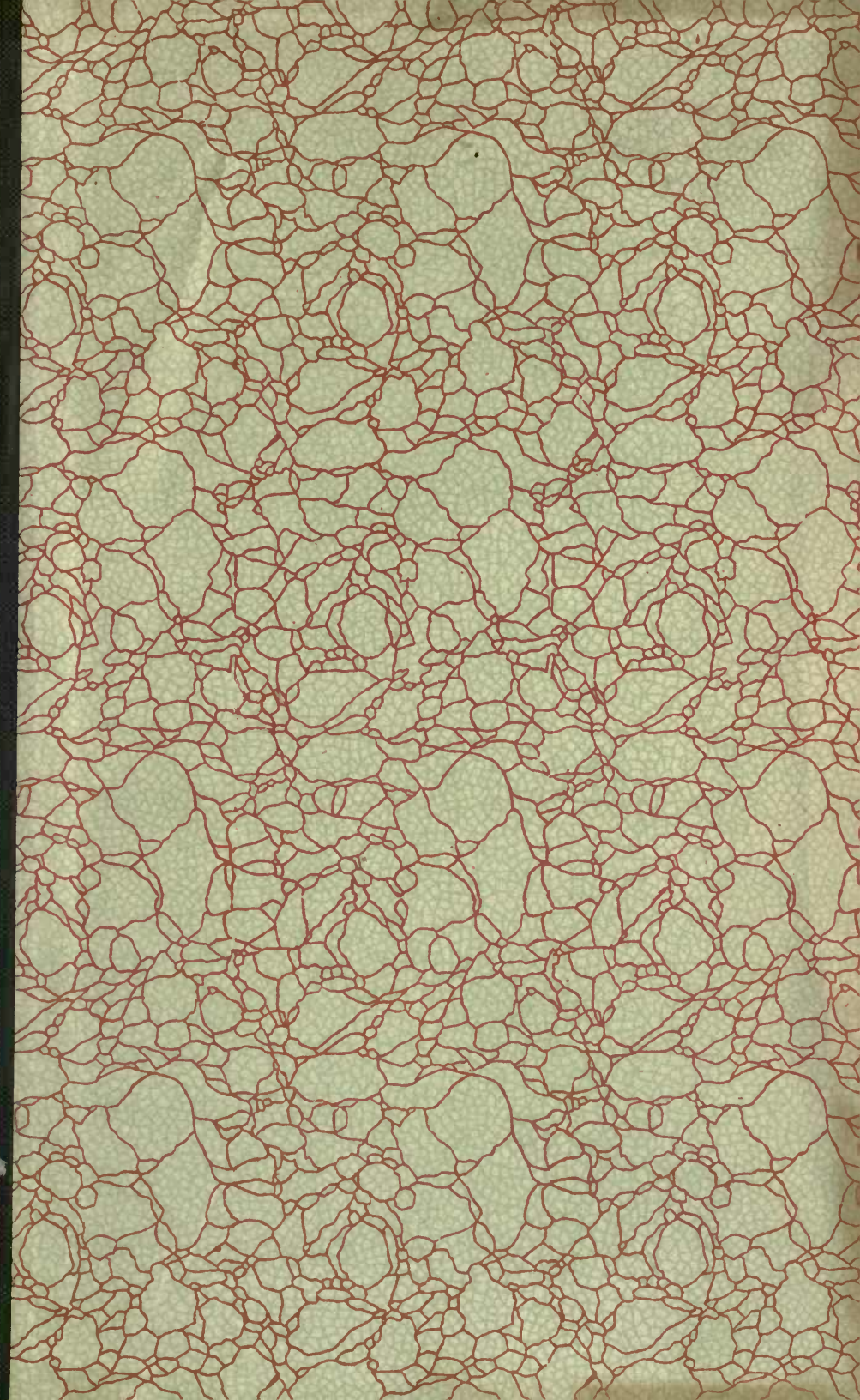
Mules.....	No. 1	No. 2	No. 3	No. 4
<i>Weight:</i>				
Weight at beginning, lbs.....	1315	1380	1325	1375
Weight at end.....	1330	1320	1305	1305
Gain or loss.....	+15	-60	-20	-70
Av. weight during trial.....	1363	1353	1320	1355
<i>Grain:</i>				
Total corn eaten, lbs.....	3381	3317	2996	3114
Total oats eaten.....	1690	1658	1498	1557
Total grain eaten.....	5072	4976	4494	4671
Av. grain per day.....	13.93	13.67	12.34	12.83
Av. grain per cwt. per day...	1.02	1.01	.93	.95
<i>Hay:</i>				
Total alfalfa eaten, lbs.....	5244	2585	4676	2397
Total timothy eaten.....	.....	2585	.....	2397
Total hay eaten.....	5244	5170	4676	4794
Av. hay per day.....	14.40	14.20	12.84	13.17
Av. hay per cwt. per day...	1.05	1.04	.97	.97
<i>Hours of labor:</i>				
Total hours labor.....	2668	2520	2665	2661
Av. hours labor per work day	8.55	8.07	8.54	8.52
Number of idle work days...	16	37	15	16

TABLE H.—SUMMARY OF 1916-17 FEEDING EXPERIMENT WITH MULES: 364 DAYS
 Ration: Ear Corn; Alfalfa

Mules.....	No. 1	No. 2	No. 3	No. 4
<i>Weight:</i>				
Weight at beginning, lbs.....	1295	1290	1270	1305
Weight at end.....	1375	1390	1240	1370
Gain or loss.....	+80	+100	-30	+65
Av. weight during trial.....	1360	1364	1298	1374
<i>Grain:</i>				
Total ear corn eaten, lbs.....	4220	4222	4030	4276
Av. ear corn per day.....	11.59	11.60	11.07	11.75
Av. ear corn per cwt. per day	.85	.85	.85	.85
<i>Alfalfa:</i>				
Total alfalfa eaten, lbs.....	6114	6114	5564	6091
Av. alfalfa per day.....	16.80	16.80	15.29	16.73
Av. alfalfa per cwt. per day.	1.23	1.23	1.18	1.22
<i>Hours of labor:</i>				
Total hours labor.....	2535	2535	2616	2616
Av. hours labor per work day	8.13	8.13	8.38	8.38
Number of idle work days...	34	34	21	21
<i>Travel:</i>				
Total miles traveled.....	3062	3062	2938	2938
Av. miles per hour.....	1.21	1.21	1.12	1.12







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